Device for determining end expiratory gases, method for determination of fluctuations in respiratory metabolism and the use of the device

Background of the Invention

Field of the Invention

The invention relates to a device for the determination of the partial pressure of at least one gas in a end expiratory gas mixture; a method for the monitoring of fluctuations in respiratory metabolism in the animal or human body and to the use thereof.

Background Information

The partial pressure of different gases in end expiratory gas mixtures is dependent upon various functions of the body - inter alia from hormonal fluctuations, disorders disturbing the respiratory metabolism such as asthma, mucoviscidosis etc. as well as upon the energy balance of the body (respiratory quotient). In various metabolic disorders or in recreatory drug abuse certain metabolic products can be detected in the end expiratory gas (diabetes, alcohol-abuse). Further the aforesaid changes during severe physical stress and therefore is an indicator for the physical ability of the body (fitness).

Especially the end expiratory gas mixture - that is the last gas volume exhaled, is an exact picture of the alveolar partial gas pressure that is again dependent on various body functions.

Until now complicated devices for measuring the actual partial gas pressure e.g. in anesthesiology have been known to measure the actual end expiratory gas pressure there. The values measured were only momentarily of interest - storage or evaluation of the stored values during a time interval was not possible. Further the known instruments were complicated and not suited for private use but for the needs of operation room conditions.

It has been found surprisingly that by measuring the end expiratory gases - especially the nd expiratory gases and evaluation thereof for body functions and metabolism can be monitored also outside of an operation room/intensive care station.

The device can be used preferably for monitoring the respiratory function, it is understood thereunder especially such disorders/conditions of the body that alter the gas content of blood. Such like asthma, chronic lung emphysema, oxygen therapy, fitness status of an athlete, i.e., for detecting the limits of performance, sleep apnoea including chronical; snoring, and inflammatory diseases of the respiratory tract.

Moreover in therapies with drugs that influence the respiratory center e.g. barbiturates, progesterone and derivatives thereof, narcotics and analgetics the actions thereof can be monitored. As well a monitoring of persons in closed rooms, such as astronauts, plungers, submarine-drivers, workers in caissons is possible.

Thereby inter alia an impairment of the function of gas exchange, i.e. the development of a chronic or acute respiratory failure, monitoring and optionally adjustment of therapy - oxygen therapy, hormonal treatment or other drug treatments can be determined.

With the ratio of ~~CO2/O2~~ O_2/CO_2 in the end expiratory volume (lungemphysem quotient) also the status of metabolism, like progress of a dietetic measure or the fitness (efficiency degree of the body) e.g. in competitive athletes or also in physical rehabilitation measures can be monitored.

A particular interesting application is th monitoring of th lung emphysema in blood by determining ~~pCO2~~ pCO_2. Since Döring: Pflügers Archiv 250 (1948), pp. 37 - 46 "About rhythmical fluctuations of breathing and body temperature in the menstrual cycle" and Döring, G. K. "About ~~rhythmical~~ fluctuations of respiration and ~~body temperature~~ cycle" Arch Gynäcol. 182 (1953), pp 746 - 758 and Döring, GK, HJ.H. Loeschke, B. Ochwadt: "Further tests about the effects of the sexual hormones on respiration" Pflügers Archiv 252 (1950), pp 216 - 230 it is known that the ~~pCO2~~ pCO_2 in women fluctuates during the menstrual cycle influenced by progesterone. It is especially significant, that in women significantly 3 - 4 days before ovulation a decline of ~~pCO2~~ pCO_2 appears. The end expiratory ~~pCO2~~ pCO_2 ~~such~~ declines a few days just before the ovulation - influenced by the rising progesterone level in blood and stays high during the luteal phase of the menstrual cycle and in pregnancy in consequence to an increased alveolar ventilation.

It has not been tried until now to use this medical phenomenon for the production of measuring devices.

Devices for ovulation detection, e.g. so called "cycle computers" that evaluate measurements of the basal body temperature or determinations of the luteinizing hormone (LH) by biochemical color reactions have always been inaccurate or gave information only very near or after the ovulation, which is useless for contraception or for the lung emphysema.

Further basal body temperature measurement is very easily ~~such~~ strongly influenced by "external circumstances" - like physical activity, disorders with fever, drugs, short sleeping period, time shifts due to air plane travel - that the measured value often is useless and thus can be used for the prediction of ovulation only with very high faults. So the known devices had the deficiency of being too inaccurate and further evaluated

body function data that can be altered strongly by the life circumstances of th patient, so that the measurement was not reliable. Further it may be interesting to monitor the fluctuations in progesterone - i.e. the pCO_2 controlled thereby during a risk pregnancy (e.g. asthma patient), to be able to manifest a decline of progesterone which endangers the pregnancy and optionally to be able to take counter-measures.

Nevertheless the measurement of other gases in the end expiratory gas can be interesting - especially as the values are readily obtained and are independent of time-consuming detection-reactions in laboratories.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a device for determination/evaluation of partial pressures of gases in an end expiratory gas volume.

According to the invention the object is met by a device that measures end expiratory gases, comprising: a receiving unit for the recieving of end expiratory gas, a measurement unit to determine the at least one gas in the thus received volume of end expiratory gas and to generate measurement signals; and a processor unit for storing and further processing of the signals measured in a predetermined time interval.

First this processor unit selects suitable measurement signals - i.e. such that are at the end of the exhalation process, as the values there are more stable and optionally an end expiratory value and effects the editing of this selected measured value into memory - optionally together with individual data about the measurement date, the measurement time, the individual herself and optionally also a further processing of the aforesaid signals by comparison with stored values. Optionally the stored values may be edited on a printer, readable and storable on conventional transportable data carriers known per se or by remote inquiry. Also a processing of individually selected

measurement values may be provided in the device - e.g. comparison with a stored measurement value table and display when deviations from the stored values greater than a predetermined threshold occur. It is also possible to monitor the variation of the values with time and to edit only the values resulting therefrom.

Preferably this unit is portable, of small dimensions and optionally battery-powered, so that it may be used on different places of the stay of the monitored individual.

Of course the device may be provided such that it measures several partial gas pressures simultaneously or sequentially - if a measurement of several gas pressures is desired. To this effect it is ~~only necessary~~ necessarily to measure different absorption bands of the gases at different places and to evaluate or to use a suitable measurement method for each gas.- e.g. commercial oxygen sensors for oxygen.

~~Preferred embodiments can be taken from the dependent claims.~~

It is advantageous if the physical measuring unit is an optical measuring unit, as optical determinations are fast and are easily converted into electrical signals.

For the measurement of polar gases, like ~~CO2~~ CO_2, it is especially preferred that the measuring cell is an IR-measuring cell, measuring an absorption band of the ~~gas/es~~ gas/gasses to be determined in a predetermined absorption wavelength area that is not absorbed by other gases, and to determine the concentration of the gas in the gas volume in a manner known per se. The invention is not delimited to IR-spectroscopic measurements - Raman spectroscopy, conductivity measurements, etc. and also usual gas sensors may be used to determine one gas in the gas mixture.

For the evaluation of a history it may be advantageous, that the values measured in a predetermined time interval are stored in a memory, that optionally may be read by an editing unit.

Typically the device has a printer as an editing unit, a readable display and/or a memory chip, that is computer-readable, so that either the value may be read visually concurrently or that the history of the values as such can be evaluated or read later.

In the special case of cycle monitoring or determination of other hormonal fluctuations, now histories of the fluctuations of the measured values can be stored together with measurement data (time, atmospheric pressure etc.) and edited - whereby complicated stationary tests can be avoided. Thereby is possible only now a comparison of different tests over a longer period of time - like cycle data. Further ~~e.g.~~ constant monitoring of the progress of a risk gestation with time is possible, without the patient having permanently to undergo complicated tests. The inventive device is especially suited for the monitoring of the pretreatment for in vitro fertilization and other procedures of assisted reproduction.

To meet this object the device may measure ~~pCO2~~ pCO_2 in the end expiratory gas only. It is preferred to determine ~~pCO2~~ pCO_2 by IR-absorption of a predetermined end expiratory gas volume in a measuring cell and to compare these values preferably either with individual basis data of the individual or to monitor only its relative fluctuation over a time interval.

As the amount of gas and thus the number of absorbing molecules in a gas volume is temperature-dependent, it is useful to thermostate the measurement cell. Otherwise

the measured value may be compensat d by computation by means of temperature value measured by a sensor in the measurement cell, whereby complicated thermostatization may be avoided - this may be especially useful in applications with high temperature fluctuations.

Preferably further a measurement unit for atmospheric pressure at the measurement time is provided and by means of the measurement the result of the measurement may be corrected for atmospheric pressure. Thereby obtaining measurement values falsified by pressure variations can be avoided. The device itself can be designed in a manner known per se as two-beam photometer.

An especially preferred use of the inventive device is the prediction of the ovulation. To such a purpose a memory for storing cycle data - optionally together with other measurement data, like temperature, is provided, that gives readings accordingly. The measured data are each compared with preceding measured data within a predetermined time interval and it is determined, whether significant deviation occurs. Thereby predication of the ovulation about three days in advance is possible - a method that is much more precise for contraception or conception than e.g. measurement of temperature, being strongly dependent on physical activity, time of the day etc. of the individual monitored.

Compared with known cycle computers that normally ~~with measurement of~~ measure the basal temperature, that is easily disturbed and thus often is imprecise, the inventive device has the advantage of a fast and precise determination independent from events like short sleeping period, physical activity etc.

A further preferred use of the device is the monitoring of pregnancy. The lowering of ~~pCO2~~ pCO_2 is typical for a normal gestation and a rise thereof is a sign of a severe disorder.

To obtain the end expiratory gas, that alone is an exact picture of the alveolar status, a device may installed, that forces the patient to exhale completely - then only those measured values are evaluated, that have been taken in the last time interval of expiration. Therefore especially units forcing the individual to exhale against an obstacle, like when inflating a balloon or the like, where the highest measured ~~pCO2~~ pCO_2 is this significant end expiratory ~~pCO2~~ pCO_2 - this may be determined in a manner known per se by a processing unit programmed accordingly, that records the measured values and evaluates the aforesaid, so that only the highest ~~pCO2~~ pCO_2 per breathing event is stored/displayed.

The process for the prediction of the ovulation i.e. of progesterone on basis of the end expiratory ~~pCO2~~ pCO_2 comprises: obtaining of a volume of end expiratory gas; determination of the IR-Absorption of the ~~CO2~~ CO_2-band in the gas volume of end expiratory gas and thus determination of the ~~pCO2~~ pCO_2 therein, correction of the result for the atmospheric pressure and temperature and editing of the measured value into an editing unit, like a memory, a printer, a display.

It may be useful to remove water vapor from the exhaled gas by absorption or condensation before the measurement cell, to obviate falsifications of the measurement result by condensation on the windows of the measurement cell.

For the use in other fields, e.g. for the monitoring of respiratory function or of fitness it is necessary to measure ~~pCO2~~ pCO_2 and ~~pO2~~ pO_2 and to form the ratio thereof. This ratio may either b stored as such or be edited or optionally compared with predetermined ratios

of the same individual or with basis data already in the device and wh n crossing a predetermined threshold value a signal is gen rated.

This signal enables the individual or his trainer (if the device is used for monitoring physical training) to alter his performance so that the body is working again in its normal range. Nevertheless, the signal may be used for controlling therapeutic measures.

Brief Description of the Drawing

In the following the invention shall be illustrated in more detail ~~with~~ under consideration of the annexed ~~drawing~~ drawings, that shows schematically an embodiment of the invention for cycle monitoring, whereas it is not meant that it be delimited thereto, shows:

Fig. 1: an embodiment of an inventive device in schematic representation; and

Fig. 2: a graph depicting ~~pCO2~~ PCO_2 dependent from cycle history.

Detailed Description of the Invention

Referring now to Fig. 1 in a preferred embodiment of the invention as a cycle computer, an inventive device comprises an IR-radiation source, the radiation thereof is directed through a gas measurement cell. In this measurement cell end expiratory gas is blown, that optionally may be dried in a manner know per se, to obviate condensation on the windows of measurement. The radiation emitted from the measurement cell is filtered by means of an optical filter onto the absorption area of the gas to be measured - in this case CO_2 - and the radiation in the predetermined area of the IR-absorption band of CO2 is directed onto an IR-sensor. Preferably the signal of the sensor is amplified in a manner known per se and then is either stored with further cycle data of the individual/further processed or simply edited on a display. It is useful that the device is enabled by a processor contain d therein to store a pCO_2 value of an exhaled volume

only, if the aforesaid does not chang much any more, to obtain an end expiratory pCO2. pCO2 value. In the embodiment with IR-~~Sensors~~ Sensors by measurement of the temp ratur , the influence of t mperature is compensat d for by computation in a manner known per se. On the other hand it is possible to climatize the measurement cell itself. The measurement of the gas is also compensated for atmospheric pressure.

Preferably the device is small and portable and may be easily transported by the user.

From Fig. 2 the physiological basis of the cycle computer may be seen, i.e. that the ~~CO2~~ CO_2 partial pressure declines significantly already about 3 - 4 days before the normally obtained values, i.e. the peak of the luteinizing hormone (LH) and of estradiol (E2) and of basal temperature and such enables a very simplified and ameliorated and especially earlier detection of the expected ovulation compared with known devices ("cycle computer").

Further embodiments and developments are obvious to the expert in the field within the scope of the claims and the scope of protection shall not be delimited to the examples, that have been referred to for illustration purposes only.